T08D01 – SL/HL Chem 2 Acids and Bases

Please log into your computer, and open up the class website

Simple A/B Calculations

- Molarity = $\frac{\text{moles of solute}}{\text{liters of solution}}$
- Dilution = $M_1V_1 = M_2V_2$
  - Where M_1 = molarity of conc, V_1 = volume of conc
  - M_2 and V_2 are of the diluted solution (or visa-versa)
- Titration = $M_aV_a = M_bV_b$
  - Where M_a = molarity of acid, V_a = volume of acid
  - M_b and V_b are of the base

Acids and Bases

- The concepts acids and bases were loosely defined as substances that change some properties of water.
- One of the criteria that was often used was taste.
- Substances were classified
  - salty-tasting
  - sour-tasting
  - sweet-tasting
  - bitter-tasting
- Sour-tasting substances would give rise to the word 'acid', which is derived from the Greek word *oxein*, which mutated into the Latin verb *acere*, which means 'to make sour'
- Vinegar is a solution of acetic acid. Citrus fruits contain citric acid.

Acids

- React with certain metals to produce hydrogen gas.
- React with carbonates and bicarbonates to produce carbon dioxide gas

Bases

- Have a bitter taste
- Feel slippery.
- Many soaps contain bases.

Properties of Acids

- ☑ Produce H^+ (as H_3O^+) ions in water (the hydronium ion is a hydrogen ion attached to a water molecule)
- ☑ Taste sour
- ☑ Corrode metals
- ☑ Good Electrolytes
- ☑ React with bases to form a salt and water
- ☑ pH is less than 7
- ☑ Turns blue litmus paper to red "Blue to Red A-CID"

Acids

Properties of Bases

- ☑ Generally produce OH^- ions in water
- ☑ Taste bitter, chalky
- ☑ Are electrolytes
- ☑ Feel soapy, slippery
- ☑ React with acids to form salts and water
- ☑ pH greater than 7
- ☑ Turns red litmus paper to blue "Basic Blue"

Bases

MORE OLD DUDES!!

Svante Arrhenius

J.N. Brønsted

Thomas Lowry

G.N. Lewis

Arrhenius Definition

Arrhenius

Acid - Substances in water that increase the concentration of hydrogen ions (H^+). Donates H^+

Base - Substances in water that increase concentration of hydroxide ions (OH^-). Donates OH^-

Categorical definition – easy to sort substances into acids and bases upon inspection of formula

Problem – many bases do not actually contain hydroxides

Bronsted-Lowry Definition

Acid - neutral molecule, anion, or cation that donates a proton.

Base - neutral molecule, anion, or cation that accepts a proton.

$$HA + B \rightarrow HB^+ + A^-$$

Ex $HCl + H_2O \rightarrow H_3O^+ + Cl^-$

Acid Base Conj Acid Conj Base

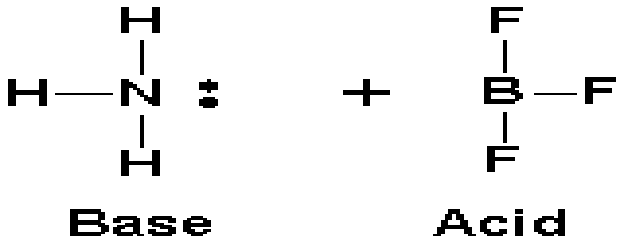
- Operational definition - The classification depends on how the substance behaves in a chemical reaction

G.N. Lewis Definition

Lewis – not commonly used

Acid - an electron pair acceptor

Base - an electron pair donor



Types of Chemical Reactions

- Single Replacement
  - One metal replaces another in a compound
- Double Replacement
  - An acid is neutralized by a base
- Combustion
  - Oxygen reacts with a hydrocarbon to produce CO_2 and H_2O
- Decomposition
  - A material is broken down, 1 material forms 2
- Synthesis
  - A new material is formed, 2 materials form 1

Neutralization

An acid will neutralize a base, giving a salt and water as products

Examples

Acid		Base		Salt		water
HCl	+	$NaOH$	→	$NaCl$	+	H_2O
H_2SO_4	+ 2	$NaOH$	→	Na_2SO_4	+ 2	H_2O
H_3PO_4	+ 3	KOH	→	K_3PO_4	+ 3	H_2O
2 HCl	+	$Ca(OH)_2$	→	$CaCl_2$	+ 2	H_2O

A **salt** is an ionic compound that is formed from the **positive ion (cation)** of the **base** and the **negative ion (anion)** of the **acid**

Neutralization Calculations

If the concentration of acid or base is expressed in Molarity or mol dm^{-3}

then:

--The volume in dm^3 multiplied by the concentration yields **moles (mol)** .

-- If the volume is expressed in cm^3 the same product yields **millimoles (mmol)**

$$\text{mol } dm^{-3} \times dm^3 = \text{mole}$$

$$\text{mol } dm^{-3} \times cm^3 = (0.001) \times \text{mole} = \text{mmol}$$

Neutralization Problems

- The volume of solution in dm^3 multiplied by concentration in moles dm^{-3} will yield moles.
- If an acid and a base combine in a 1 to 1 ratio, the moles of acid will equal the moles of base.
- Therefore the volume of the acid multiplied by the concentration of the acid is equal to the volume of the base multiplied by the concentration of the base.

$$M_{acid} V_{acid} = M_{base} V_{base}$$

If any three of the variables are known, it is possible to determine the fourth.

Neutralization Problems

Example 1: **Hydrochloric acid reacts with potassium hydroxide according to the following reaction:**

$$HCl + KOH \rightarrow KCl + H_2O$$

If 15.00 cm^3 of 0.500 M HCl exactly neutralizes 24.00 cm^3 of KOH solution, what is the concentration of the KOH solution?

Solution:

$$M_{acid}\,V_{acid} = M_{base}\,V_{base}$$

$$(0.500\ M)\ (15.00\ cm^3) = M_{base}(24.00\ cm^3)$$

$$M_{base} = \frac{(15.00\ cm^3)(0.500\ M)}{(24.00\ cm^3)}$$

$$M_{base} = 0.313\ M$$

Neutralization Problems

Whenever an acid and a base do not combine in a 1 to 1 ratio, a mole factor must be added to the neutralization equation

$$n\, M_{acid}\, V_{acid} = M_{base}\, V_{base}$$

The mole factor (n) is the number of times the moles the acid side of the above equation must be multiplied so as to equal the base side. (or vice versa)

Example

$$H_2SO_4 + 2\,NaOH \rightarrow Na_2SO_4 + 2\,H_2O$$

The mole factor is 2 and goes on the acid side of the equation. The number of moles of H_2SO_4 is one half that of NaOH. Therefore the moles of H_2SO_4 are multiplied by 2 to equal the moles of NaOH.

Protic = Protons = H^+

- Monoprotic = 1 proton to donate
  - HCl, HNO_3, $HC_2H_3O_2$
- Diprotic = 2 protons to donate
  - H_2CO_3, H_2SO_4, H_2S
- Triprotic = 3 protons to donate
  - H_3PO_4, H_3N

Neutralization Problems

Example 2: **Sulfuric acid reacts with sodium hydroxide according to the following reaction:**

$$H_2SO_4 + 2\,NaOH \rightarrow Na_2SO_4 + 2\,H_2O$$

If 20.00 cm^3 of 0.400 M H_2SO_4 exactly neutralizes 32.00 cm^3 of NaOH solution, what is the concentration of the NaOH solution?

Solution:

In this case the mole factor is 2 and it goes on the acid side, since the mole ratio of acid to base is 1 to 2. Therefore

$$2\,M_{acid}\,V_{acid} = M_{base}\,V_{base}$$

$$2\,(0.400\ M)\,(20.00\ cm^3) = M_{base}(32.00\ cm^3)$$

$$M_{base} = \frac{(2)\,(20.00\ cm^3)(0.400\ M)}{(32.00\ cm^3)}$$

$$M_{base} = 0.500\ M$$

Neutralization Problems

Example 3: **Phosphoric acid reacts with potassium hydroxide according to the following reaction:**

$$H_3PO_4 + 3\,KOH \rightarrow K_3PO_4 + 3\,H_2O$$

If 30.00 cm^3 of 0.300 M KOH exactly neutralizes 15.00 cm^3 of H_3PO_4 solution, what is the concentration of the H_3PO_4 solution?

Solution:

In this case the mole factor is 3 and it goes on the acid side, since the mole ratio of acid to base is 1 to 2. Therefore

$$3\,M_{acid}\,V_{acid} = M_{base}\,V_{base}$$

$$3\,(M_{acid})\,(15.00\ cm^3) = (0.300\ M)(30.00\ cm^3)$$

$$M_{acid} = \frac{(30.00\ cm^3)(0.300\ M)}{(3)\,(15.00\ cm^3)}$$

$$M_{acid} = 0.200\ M$$

Neutralization Problems

Example 4: **Hydrochloric acid reacts with calcium hydroxide according to the following reaction:**

$$2\ HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2\ H_2O$$

If 25.00 cm^3 of 0.400 M HCl exactly neutralizes 20.00 cm^3 of $Ca(OH)_2$ solution, what is the concentration of the $Ca(OH)_2$ solution?

Solution:

In this case the mole factor is 2 and it goes on the base side, since the mole ratio of acid to base is 2 to 1. Therefore

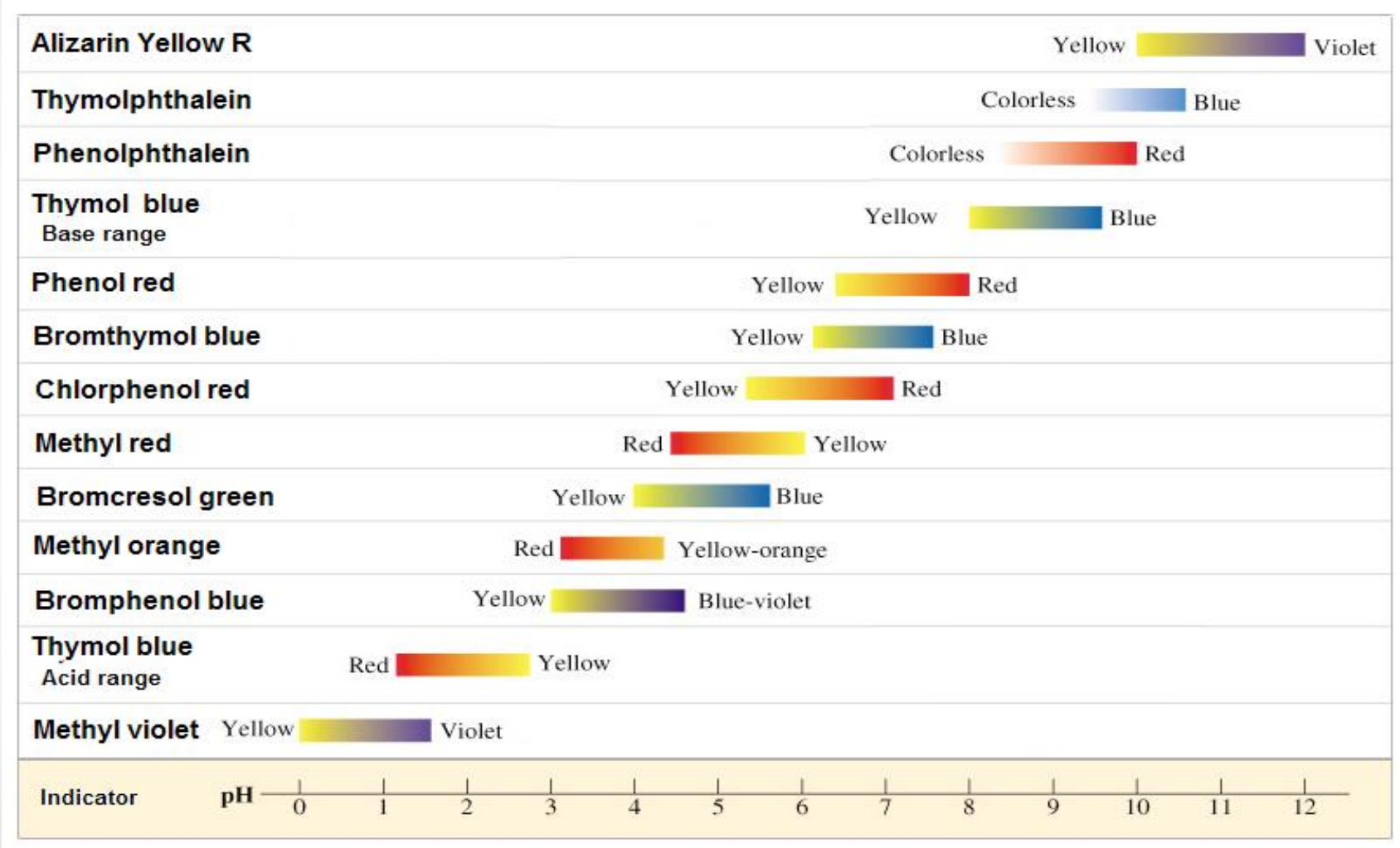
$$M_{acid}\ V_{acid} = 2\ M_{base}\ V_{base}$$

$$(0.400)(25.00\ cm^3) = (2)\ (M_{base})(20.00\ cm^3)$$

$$M_{base} = \frac{(25.00\ cm^3)\ (0.400\ M)}{(2)\ (20.00\ cm^3)}$$

$$M_{base} = 0.250\ M$$

Indicators


Alizarin Yellow R
Yellow
Violet
Thymolphthalein
Colorless
Blue
Phenolphthalein
Colorless
Red
Thymol blue
Base range
Yellow
Blue
Phenol red
Yellow
Red
Bromthymol blue
Yellow
Blue
Chlorphenol red
Yellow
Red
Methyl red
Red
Yellow
Bromcresol green
Yellow
Blue
Methyl orange
Red
Yellow-orange
Bromphenol blue
Yellow
Blue-violet
Thymol blue
Acid range
Red
Yellow
Methyl violet
Yellow
Violet
Indicator
pH
0
1
2
3
4
5
6
7
8
9
10
11
12